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<b>UTILITY PATENT APPLICATION TRANSMITTAL</b> (Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))	Attorney Docket No.	ASI-PT043
	First Inventor or Application Identifier	Veksland et al.
	Title	AUTOMATIC FOCUSING CAMERA WITH MOVING MIRROR BETWEEN FIXED LENS AND FIXED IMAGE SENSOR
	Express Mail Label No.	EL413096649US

<b>APPLICATION ELEMENTS</b> See MPEP chapter 600 concerning utility patent application contents.	<b>ADDRESS TO:</b> Assistant Commissioner for Patents Box Patent Application Washington, DC 20231
1. <input checked="" type="checkbox"/> * Fee Transmittal Form (e.g., PTO/SB/17) (Submit an original and a duplicate for fee processing)	5. <input type="checkbox"/> Microfiche Computer Program (Appendix)
2. <input checked="" type="checkbox"/> Specification [Total Pages 12] (preferred arrangement set forth below) <ul style="list-style-type: none"><li>- Descriptive title of the Invention</li><li>- Cross References to Related Applications</li><li>- Statement Regarding Fed sponsored R &amp; D</li><li>- Reference to Microfiche Appendix</li><li>- Background of the Invention</li><li>- Brief Summary of the Invention</li><li>- Brief Description of the Drawings (if filed)</li><li>- Detailed Description</li><li>- Claim(s)</li><li>- Abstract of the Disclosure</li></ul>	6. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary) <ul style="list-style-type: none"><li>a. <input type="checkbox"/> Computer Readable Copy</li><li>b. <input type="checkbox"/> Paper Copy (identical to computer copy)</li><li>c. <input type="checkbox"/> Statement verifying identity of above copies</li></ul>
3. <input checked="" type="checkbox"/> Drawing(s) (35 U.S.C. 113) [Total Sheets 2]	<b>ACCOMPANYING APPLICATION PARTS</b>
4. Oath or Declaration [Total Pages 3] <ul style="list-style-type: none"><li>a. <input checked="" type="checkbox"/> Newly executed (original or copy)</li><li>b. <input type="checkbox"/> Copy from a prior application (37 C.F.R. § 1.63(d)) (for continuation/divisional with Box 16 completed)<ul style="list-style-type: none"><li>i. <input type="checkbox"/> DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).</li></ul></li></ul>	7. <input checked="" type="checkbox"/> Assignment Papers (cover sheet & document(s))
<b>*NOTE FOR ITEMS 1 &amp; 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).</b>	8. <input type="checkbox"/> 37 C.F.R. § 3.73(b) Statement of Power of Attorney (when there is an assignee)
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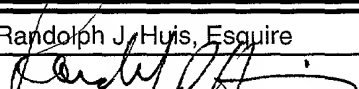
Prior application information: Examiner: \_\_\_\_\_ Group / Art Unit: \_\_\_\_\_

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TITLE OF THE INVENTION

Automatic Focusing Camera With Moving Mirror Between Fixed  
Lens And Fixed Image Sensor

BACKGROUND OF THE INVENTION

The present invention is directed to an automatic focusing camera, and more particularly to an automatic focusing line scan camera for use in scanning applications.

In scanning applications, for examples for packages traveling along a conveyor, it is often required that scans be carried out at varying target distances. For example, if a larger package moves along a conveyor beneath a scanner, the distance between the lens of the scanning camera system and the object is shorter than for a smaller package traveling along the same conveyor path. Prior known systems generally provide focusing for the scanning camera by adjusting the position of the lens system or the image sensor to focus the image plane on the sensor. However, this can result in higher costs for systems employing movement of one or more lens in order to maintain the optical alignment of the lens relative to one another and the sensor. Additionally, movement of the image sensor can add additional complexity and cost due to the need to provide electrical connections to an from the imaging sensor and to maintain the desired orientation of the sensor over the path of movement.

It would be desirable to be able to provide adjustment of the object focal length without the need for moving either the lens system (or one or more lenses therein) or the sensor relative to one another in order to provide a simple and reliable automatic focusing system for a camera system, preferably for use in scanning applications.

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## SUMMARY OF THE INVENTION

Briefly stated, the present invention is an automatic focusing camera which includes an image sensor. A fixed lens system is provided having a lens with an object side and an image side. The fixed lens system is located in a fixed position relative to the image sensor. A mirror is moveably positioned between the image side of the lens system and the image sensor. The mirror is located at an angle such that an image observed through the fixed lens system is reflected toward the image sensor. An actuator is connected to the mirror and moves the mirror relative to the lens system to change a distance between the lens system and the image sensor to adjust an object focal length between an object and the camera.

In another aspect, the present invention provides a method for automatic focusing of a camera having an image sensor and a lens system with an objective lens located at a fixed position relative to the image sensor. The method comprises: (a) providing a mirror moveably mounted between an image side of the lens system and the image sensor; and (b) adjusting the position of the mirror to vary a length of an optical path between the image sensor and the lens system to vary an object focal point on an object being observed.

## BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The foregoing summary, as well as the following detailed description of the preferred embodiments of the invention will be better understood when read in conjunction with the appended drawings. For the purposes of illustrating the invention, there is shown in the drawings embodiments which are presently preferred. It should be understood, however, that the invention is not limited to precise arrangements shown. In the drawings:

**Fig. 1** is a plan view of the automatic focusing camera in accordance with the present invention;

**Fig. 2** is a plan view of a second embodiment of an automatic focusing camera in accordance with the present invention;

**Fig. 3** is a plan view of the automatic focusing camera shown in Fig. 2 illustrating the shift in the object focal line as the object focal point moves farther from or nearer to the lens system.

## DETAILED DESCRIPTION OF THE INVENTION

Certain terminology is used in the following description for convenience only and is not considered limiting. The words "right", "left", "lower", and "upper" designate directions in the drawings to which reference is made. The terminology includes the words specifically noted above, derivatives thereof and words of similar import. Additionally, the terms "a" and "one" are defined as including one or more of a referenced item unless specifically noted.

Referring to the drawings, wherein like numerals designate like elements throughout, there is shown in **Fig. 1** a preferred embodiment of an automatic focusing camera **10** in accordance with the present invention. Preferably, the automatic focusing camera **10** is a line scan camera and includes an image sensor **12** and a fixed lens system **14** having an objective lens **16** with an object side **16a** and an image side **16b**. The fixed lens system **14** is located in a fixed position relative to the image sensor **12**, for example by fixed mounting of the image sensor **12** and the lens system **14** on a common substrate, for example a circuit board. The fixed lens system **14** has an optical axis **22**. While the fixed lens system **14** is illustrated as including a single objective lens in the first preferred embodiment of the invention **10**, it will be recognized by those skilled in the art from the present disclosure that the fixed lens system **14** may include multiple lenses, depending upon the particular application. However, in accordance with the present invention, it is contemplated that if multiple lens are provided, the lenses would be adjusted to a fixed, in-use position relative to the other lenses as well as the image sensor **12**, and that the automatic focusing of the camera **10** would be carried out without further adjustment to the lens system **14**.

Still with reference to **Fig. 1**, a mirror **20** is positioned between the image side **16b** of the lens system **14** and the image sensor **12**. The mirror **20** is located at an angle such that an image located along the optical axis **22** is observed through the fixed lens system **14** and is reflected toward the image sensor **12**. This is illustrated most clearly by the path of the

optical axis **22** of the lens system **14** which is reflected by the mirror **20** toward the image sensor **12** generally along a path **32** normal to the face of the image sensor **12**.

An actuator **24** is connected to the mirror **20** that moves the mirror **20** relative to the lens system **14** to change a distance between the lens system **14** and the image sensor **12** to adjust an object focal length between an object (not shown in **Fig. 1**) and the camera **10**. As shown in **Fig. 1**, preferably the mirror **20** is mounted on an arm **28** having a pivot point **30** located along an optical axis **32** of the image sensor **12**. The actuator **24** is connected to the mirror **20** via the arm **28**. Preferably, the pivot point **30** is located on an opposite side of the image sensor **12** from the mirror **20** and is offset sufficiently such that pivoting movement of the arm **28** approximates linear movement over the range of motion for the mirror **20**.

In a preferred embodiment, the actuator **24** is a voice coil. However, those skilled in the art will understand from the present disclosure that the actuator **24** may be constructed as a solenoid or a stepper motor with a lead screw or using any other suitable controllable displacement means. In the first preferred embodiment, the pivot point **30** is formed by a pin connection. However, it will be recognized by those skilled in the art from the present disclosure that the pivot could be provided by a flexible member such as a leaf spring or a living hinge which would provide the additional advantage of biasing the arm **28** in a given direction to maintain greater stability of the mirror **20**, if desired.

As shown in **Fig. 1**, when the actuator **24** is actuated, the arm **28** can be adjusted to a second position, shown in dashed lines as **28'**, moving the mirror **20** to a second position

shown as **20'** to adjust the length of the optical path between the lens system **14** and the image sensor **12**. This causes the object focal point to vary in a predictable manner as explained in more detail below.

In the preferred embodiment, the focusing mechanism is used in conjunction with a line-scan camera system, such as a line-scan CCD camera as the image sensor **12**. This is due to the fact that if the object plane and the nodal plane of the lens system **14** are parallel, then the image plane at the image sensor **12** must also be parallel to both the object and nodal planes in order for a complete image to be in focus. The pivoting of the mirror **20** in the first preferred embodiment causes the sensor plane to be non-parallel to the lens nodal plane resulting in an out-of-focus condition for all except a single line in the sensor plane across the face of the image sensor **12**. However, as long the image sensor **12** is a single-line sensor located at this line of perfect focus, then the image sensor **12** will see the object without distortion. This is especially useful for scanning applications where a single scan line is generally being observed and imaged by the camera **10**.

Referring now to **Fig. 2**, a second preferred embodiment of the automatic focusing camera **110** is shown. The second preferred embodiment of the automatic focusing camera **110** is similar to the first embodiment **10** and like elements have been designated with the same reference numerals. The differences between the automatic focusing camera **110** of the second preferred embodiment of the invention and the automatic focusing camera **10** of the first embodiment of the invention are explained in detail below.

In the second preferred embodiment of the invention, the automatic focusing camera 110 includes a mirror 120 which is mounted for generally linear movement parallel to the optical axis 22 of the lens system 14. Preferably, the mirror 120 is connected to a linear actuator 124 for movement of the mirror 120 from a first position to a second position 120', as shown by dashed lines in Fig. 2, to change the length of the optical path between the lens system 14 and the image sensor 12. In the second preferred embodiment of the automatic focusing camera 110, since the actuator 124 causes the mirror 120 to move linearly along a path generally parallel to the optical axis 22 of the lens system 14, the object, lens and sensor planes all remain parallel such that the image can be focused on the surface of the image sensor 12. However, the field of view of the image sensor 12 moves orthogonally to the sensor line as shown in Fig. 3. This results in a shift of the object focal line 123 up or down (for example to the position indicated by 123') as the focal point moves farther from or nearer to the lens system 14, respectively. As shown by comparing the first position of the lens 120 in Fig. 2 with the object focal line 123 in Fig. 3 versus the second position of the lens 120' in Fig. 2 and the second object focal line 123' in Fig. 3, this shift becomes apparent.

While in the second preferred embodiment a line-scan camera is also used as the image sensor 12, it is also possible to utilize a two dimensional image sensor 12 in connection with the second preferred embodiment since the object, lens and sensor planes all remain parallel to the field of view of the image sensor 12.



In use, the position of the mirrors **20, 120** of the automatic focusing cameras **10, 110** are adjusted to vary a length of an optical path between the imaging sensor **12** and the lens system **14** to vary an object focal point on an object being observed. In the first preferred embodiment, this is accomplished by moving the mirror about the pivot point **30**, shown in **Fig. 1**, and receiving the image to be scanned on a single line-scan camera, such as a single line CCD camera. In the second preferred embodiment, the mirror **120** is moved linearly along a path parallel to an optical axis **22** of the lens system **14**, as shown in **Fig. 2**, to adjust the position of the mirror **120** in order to focus the object image on the image sensor **12**.

While the preferred embodiments of the invention have been described in detail, the invention is not limited to the specific embodiments described above which should be considered as merely exemplary. Further modifications and extensions of the present invention may be developed, and all such modifications are deemed to be within the scope and spirit of the present invention as defined by the appended claims and all legal equivalents thereto.

## CLAIMS

What is claimed is:

1. Automatic focusing camera comprising:

an image sensor;

5 a fixed lens system having a lens with an object side and an image side, the fixed lens system being located in a fixed position relative to the image sensor;

a mirror movably positioned between the image side of the lens and the image sensor, the mirror being located at an angle such that an image observed through the fixed lens system is reflected toward the image sensor; and

10 an actuator connected to the mirror that moves the mirror relative to the lens system to change a distance between the lens system and the image sensor to adjust an object focal length between an object and the camera.

2. The automatic focusing camera of claim 1, wherein the mirror is mounted on an arm having a pivot point located along an optical axis of the image sensor and the actuator  
15 is connected to the mirror via the arm.

3. The automatic focusing camera of claim 2, wherein the pivot point is located on an opposite side of the image sensor from the mirror.

4. The automatic focusing camera of claim 1, wherein the actuator is a voice coil.

5. The automatic focusing camera of claim 1, wherein the mirror is mounted for generally linear movement parallel to an optical axis of the lens system.

6. The automatic focusing camera of claim 1, wherein the sensor is a single line sensor.

7. Method for automatic focusing of a camera having an image sensor and a lens system with a lens located at a fixed position relative to the image sensor, comprising:

providing a mirror movably mounted between an image side of the lens system and the image sensor; and

adjusting the position of the mirror to vary a length of an optical path between the imaging sensor and the lens system to vary an object focal point on an object being observed.

8. Method for automatic focusing of claim 7, further comprising:

moving the mirror linearly along a path parallel to an optical axis of the lens system to adjust the position of the mirror.

9. Method for automatic focusing of claim 7, further comprising:

moving the mirror about a pivot point located along an optical axis of the image sensor; and

receiving an image to be scanned as a single line in a plane of the image sensor.

## ABSTRACT

An automatic focusing camera which includes an image sensor is provided having a fixed lens system with a lens having an object side and an image side. The fixed lens system is located in a fixed position relative to the image sensor. A mirror is moveably positioned between the image side of at least one lens and the image sensor. The mirror is located at an angle such that an image observed through the fixed lens system is reflected toward the image sensor. An actuator is connected to the mirror and moves the mirror relative to the lens system to change a distance between the lens system and the image sensor to adjust an object focal length between an object and the object side of the lens.

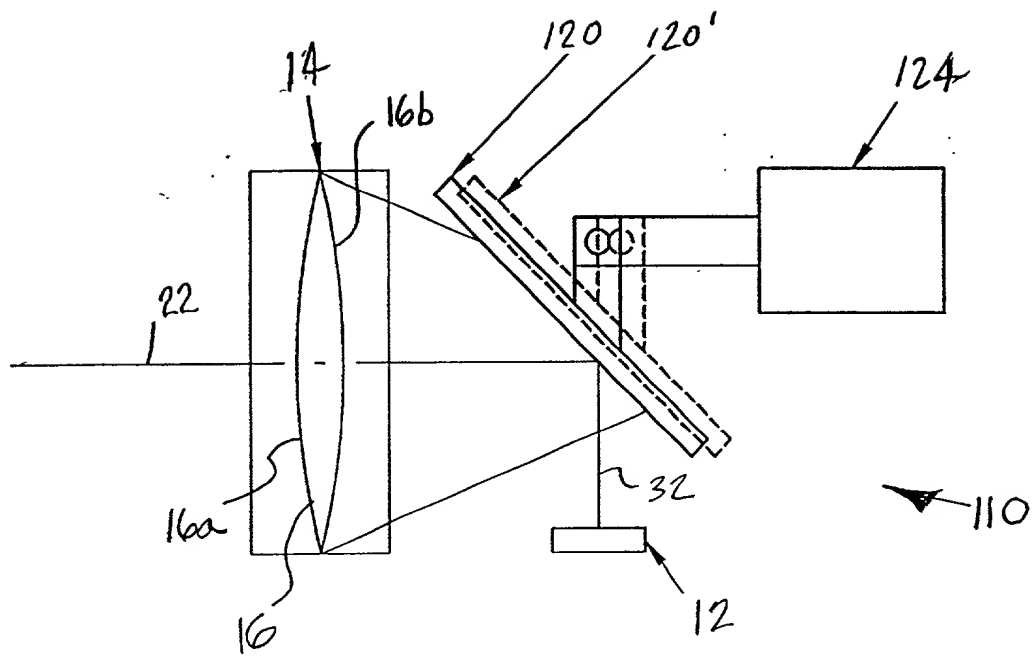


FIG. 2

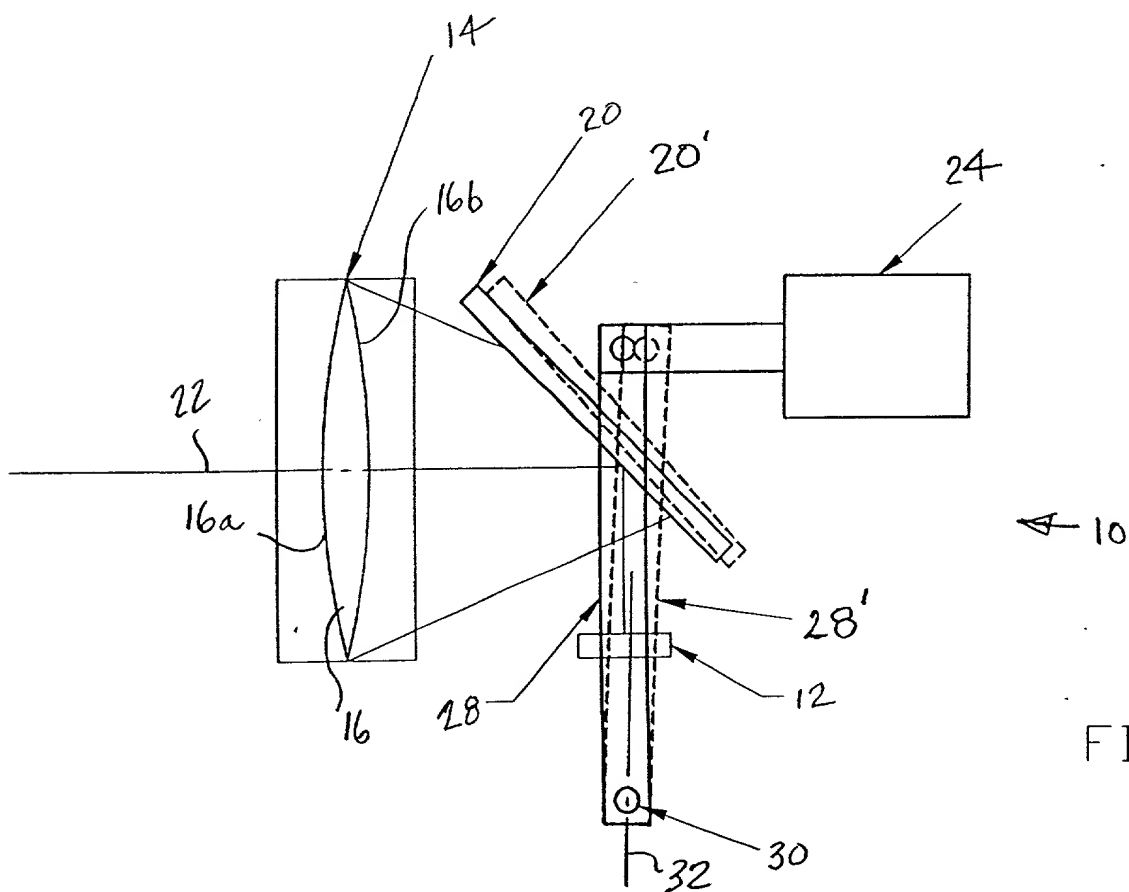


FIG. 1

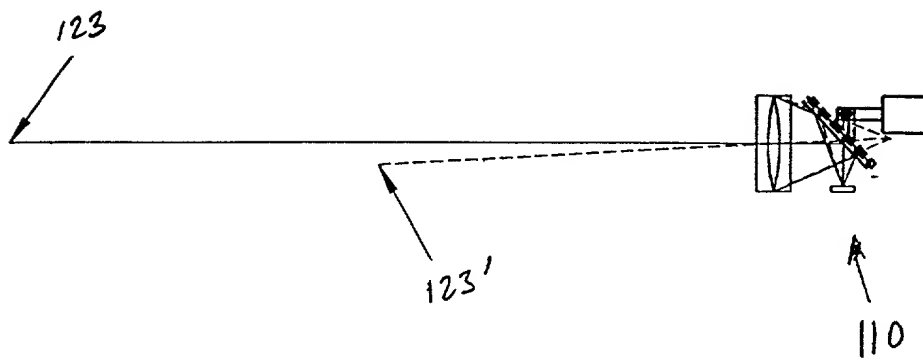


FIG. 3

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	<b>First Named Inventor</b>	Veksland et al.
	<b>COMPLETE IF KNOWN</b>	
	<b>Application Number</b>	
	<b>Filing Date</b>	
	<b>Group Art Unit</b>	
	<b>Examiner Name</b>	

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My residence, post office address, and citizenship are as stated below next to my name

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

**AUTOMATIC FOCUSING CAMERA WITH MOVING  
MIRROR BETWEEN FIXED LENS AND FIXED IMAGE SENSOR**

the specification of which (Title of the Invention)

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OR  
☐ was filed on (MM/DD/YYYY) [ ] as United States Application Number or PCT International

Application Number [ ] and was amended on (MM/DD/YYYY) [ ] (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

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Application Number(s)	Filing Date (MM/DD/YYYY)	
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U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

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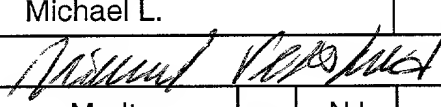
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Name of Sole or First Inventor:

☐ A petition has been filed for this unsigned inventor

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☒ Additional inventors are being named on the 1 supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

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**DECLARATION**

**ADDITIONAL INVENTOR(S)**  
**Supplemental Sheet**  
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<b>Name of Additional Joint Inventor, if any:</b>				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
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Post Office Address	105 Julian Drive East						
Post Office Address							
City	Warwick	State	PA	ZIP	18974	Country	USA
<b>Name of Additional Joint Inventor, if any:</b>				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
Given Name (first and middle [if any])				Family Name or Surname			
Inventor's Signature						Date	
Residence: City		State		Country		Citizenship	
Post Office Address							
Post Office Address							
City		State		ZIP		Country	
<b>Name of Additional Joint Inventor, if any:</b>				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
Given Name (first and middle [if any])				Family Name or Surname			
Inventor's Signature						Date	
Residence: City		State		Country		Citizenship	
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